C02-01 Reliability of Optical Interfaces to MEMS

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Objectives: Develop methods for assessing the reliability of optical interfaces to MEMS packages and use those methods to address the reliability of glass tape sealed hermetic optical waveguide MEMS packages and metalized optical fiber interfaces to chip-level MEMS packages.

Background: Micro-opto-electro-mechanical systems (MOEMS) share the traditional challenges of MEMS with the additional issues of optical interconnects and mirror contamination. The challenges posed by optical interconnects pales in comparison to the potential payoff. Traditionally, switching in the telecommunication industry is performed electrically, even in optical networks. MOEMS offers significant savings in power, cost, and volume. More importantly, it eliminates bottlenecks at the electrical switch or router. MOEMS is expected to have a huge impact on the telecommunications market. The optical component market, in general, is projected to grow anywhere from 35% to 50% per year for the next several years.

As a subset of MEMS packaging, MOEMS are primarily hermetic. The reliability of the packaged device and the repeatability of the packaging process are the major hurdles to commercialization of MOEMS. Optical interconnects for MOEMS have historically consisted of the fiber through a wall. However, waveguides and windows have been shown to be feasible alternatives to the fiber optic interconnect.

Very little literature exists on the packaging of optical interconnects. Even less is published on MOEMS optical interconnects. Optical interconnection methods are highly guarded trade secrets, even regarding the traditional fiber to carrier seal. Current efforts in MEM/MOEMS packaging at the universities are not focused on optical interconnection, but rather on lens alignment. DARPA funded projects utilize waveguide interconnects, none appear to address interconnects with fibers at this time.

Approach: Two different optical interconnections to MEMS will be considered in this project: 1) an optical waveguide, and 2) an optical fiber. The approach and planned work for these two structures is outlined below:

1. Hermetic optical waveguide structure (MOEMS). The target structure is being developed by D. DeVoe (University of Maryland) and consists of a SiO_2 optical waveguide fabricated within a silicon chip. The chip also contains a MEMS at one end of the waveguide and a silicon cap chip bonded with glass tape to create a hermetic cavity for the MEMS. Work on this structure will leverage off the work completed in the C99-52, C00-45, and C01-06 projects and focus on assessing the reliability of the glass tape bond and the hermeticity of the cavity.
2. Metalized optical fiber connected to a chip-level hermetic MEMS package. The target structure is being designed by NSWC and will initially be fabricated by Cronos. The test structure consists of a chip with fiber channels etched using DRIE, into which fibers are laid. A cap chip (either DRIE or KOH etched) is added to cover the remainder of the fiber. Solder must be reflowed into the space between the fiber and the top and bottom chip to form a hermetic seal between the metalized fiber and the silicon.

For the optical fiber structures, the vias will be screened for hermeticity after reflow of the solder. Leak testing will be performed as prescribed in method 1014 of MIL-STD-883E. The gross leak testing will not require special handling.

For both test vehicles a fine leak test will be performed in which the package is immersed in pressurized helium in an attempt to drive the helium into tiny holes in the package. The package in then placed into a mass spectrometer where trace amounts of helium can be detected. In a standard hermetic IC package, the detected helium is that which is exiting the package. In the fiber case, the ends of the fiber within the package will be plated so that the fiber cannot absorb helium.

Milestones, Deliverables and Schedule:

- Assess glass tape bonded wafers – November 2001
- Test plan for glass tape bonded waveguide structures - January 2002
- Summary report of glass tape sealed waveguide structures = July 2002
- Solder reflow modeling to determine effect of shape on reflowing solder around metalized fiber – March 2002
- Test plan for metalized fiber structures – October 2002

ID	Task Name
1	**Optical waveguide structure**
2	Assess delamination measurement methodology on bonded wafers
3	Test plan development
4	Test plan
5	Environmental testing
6	Summary report
7	**Metalized fiber structure**
8	Model solder reflow
9	Fabricate test chips
10	Assemble test structures
11	Hermiticity evaluation of assemblies
12	Test plan development
13	Test plan
14	Environmental testing